

The Increasing Role of Robots in National Security

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When most people think of national security and the global war on terrorism, they often focus on the activities taking place in Afghanistan and Iraq. However, the war on terrorism is genuinely global and is being fought in many places beyond U.S. Central Command's area of responsibility in the Middle East and the Horn of Africa. From Asia to South America, servicemembers are pursuing multiple strategies to prevent the planning and execution of terrorist attacks. These strategies involve working with our partner nations around the world to conduct humanitarian missions, secure their borders, exchange intelligence, and help train their militaries. A major challenge for the Department of Defense is that there are various issues in many parts of the world and only so many personnel to go around.

So how can we continue to effectively prosecute numerous missions in so many different locations? We must give the servicemembers better tools—such as robots.

Already in Afghanistan and Iraq, servicemembers have embraced a new world in which man and robot work side by side. In 2001, there were only 120 tele-operated robots in theater, conducting cave reconnaissance. Today, ground robots have increased their presence in theater to nearly 6,000, and more are on the way. The robots still conduct reconnaissance, but they also assist with vehicle inspection, roadside inspection, and defeat of improvised explosive devices. Thousands of lives have been saved, thanks to robots that were able to neutralize IEDs before the devices could maim or kill U.S. troops or innocent civilians. Operators have become so adept at the robots' use and so attached to them that they name them and think of them as members of the team.

Potential New Military Uses for Robots

We are only at the beginning of what is likely to be a long and growing relationship between robots and DoD personnel. The technology of robotics is growing by leaps and



The Battlefield Extraction Assist Robot (BEAR) is designed to rescue wounded troops and reduce the risk to medics.

Photograph courtesy of Vecna Technologies, Inc.

bounds, thanks largely to funding and oversight by DoD's acquisition and technology organizations. In laboratories today, robots are being developed to carry equipment for dismounted soldiers traveling on foot in extreme terrain. Robots are being designed to rescue the wounded, stand sentry duty, detect and neutralize mines, clear ranges of

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unexploded ordnance, search for dirty bombs, and more. What is so important is not that robots will replace personnel, but that they will allow the same number of personnel to do more, over larger areas of responsibility—exactly what is needed for increased national security.

In U.S. Southern Command's area of responsibility in Central and South America and the Caribbean, one of the most significant threats to national security is the drug trade and narco-terrorism. Drug revenues finance and equip terrorists and insurgents, so if the movement of drugs can be interdicted, then funding for insurgents dries up. A significant challenge for SOUTHCOM is the immense variety of mountainous and jungle terrain that is difficult to see and maneuver through, for which reasons, it is a haven for drug traffickers and insurgents. Since so much of the drug trade operates in jungle conditions, and transport is largely conducted by river, SOUTHCOM is exploring whether different robotic systems could operate together to conduct reconnaissance and interdiction missions.

Reduced Risk of Casualty

Unmanned aerial vehicles equipped with foliage-penetrating radar could potentially scout areas of interest. If suspicious activity is detected, the aerial vehicle would then send global positioning system coordinates to unmanned

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izes on the advantages of robotics. Robots can operate for long periods without becoming fatigued and losing their sharp perception—they don't get tired or hungry—and they keep personnel from being detected and harmed by insurgents.

In addition to battling drug trafficking, SOUTHCOM also operates in areas beset by IEDs and anti-personnel mines. SOUTHCOM is working with partner nation Chile to eliminate anti-personnel mines using another ground robot that has the ability to clear unexploded ordnance day and night, three times faster than human beings and at one third less cost, according to preliminary testing. Beyond the obvious benefit of eliminating the hazards of mines to innocent civilians, there is also the additional payback of reclaiming formerly unusable land for agricultural or economic purposes. A third-order effect is increased security for Chile because as the newly usable land becomes productive, further resources are available to address security issues.

U.S. Pacific Command is also challenged by extreme terrain in its area of responsibility in the Asia-Pacific region. PACOM is exploring the possibility that robots can help carry gear into areas unreachable by ships, aircraft, or land vehicles. Although still in the early development stage, the Defense Advanced Research Project Agency's "BigDog" has caught the attention of PACOM. BigDog is a robotic pack mule that shows great promise in autonomously traversing difficult terrain that must be traveled on foot. This would be of great benefit to today's servicemembers, who are often asked to carry over 120 pounds of

gear—an extremely fatiguing activity in high temperature and humidity conditions.

One of the most dangerous missions for Army medics is the rescue of a wounded soldier. Not only is the wounded soldier at risk, but medics could also be wounded or killed trying to reach and extract their injured comrade. The



The iRobot PackBot searches for explosives.
Photograph courtesy of iRobot Corp.

vehicles on the ground or on a river, enabling the vehicles to conduct reconnaissance closer to the area of interest. Vast areas could be covered by the unmanned systems, and personnel would be sent in only after confirmation that interdiction is warranted. This is an idea that capital-

U.S. Army Medical Research and Materiel Command sees robots as a better way to carry wounded soldiers to safety. The Battlefield Extraction Assist Robot is a promising system in early development. BEAR is required to carry up to 300 pounds and navigate inside buildings, traversing up and down stairs, while carrying a wounded soldier in a way that does not add to his or her injuries.

We Have the Technology. Now How Do We Integrate It?

While DoD is pursuing a wide variety of robotic applications, successfully integrating them into the armed forces requires more than just success in the laboratory. It also requires an understanding of how to actually employ the technology in real-world conditions, in which one may be called upon to perform quite different missions from usual. Determining how to integrate robots is not easy, partly because there are relatively few robots currently in

use within the armed forces, and also because there are just not many people in DoD (or the world, for that matter) who have much experience working with them.

A current effort associated with using robotic vehicles in convoys provides an example of what must be considered and resolved before integrating and deploying robots in the field. The military uses convoys all over the world to move supplies and maneuver units from one point to another. Current robotic technology is not mature enough for supply trucks to follow one another in a convoy over a protracted route with no human drivers at all. However, the technology *has* developed to the point where certain vehicle-driving tasks can be performed by the trucks themselves. So now technical experts, military planners, and end-users must work together to consider when, how, and to what extent convoy missions might be conducted using robotic technology.

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The answers are not immediately obvious, and many more questions have arisen as various integration scenarios are analyzed. For example:

- If an autonomous truck can drive itself by following a truck in front with a human driver, how many such vehicles should make up a typical convoy—three, a dozen, 40, or some number in between?
- Can the autonomous “follower” vehicle react to unexpected obstacles in the road, such as a deer suddenly running between it and the lead truck?
- How closely should an autonomous vehicle follow the lead vehicle?
- How far apart can the vehicles be while still maintaining the integrity of the convoy?
- How many people are still needed to adequately move the convoy (drive the lead vehicles, provide security, load and unload the trucks, etc.)?
- What ratio and position of trucks with drivers, relative to those without drivers, will provide the most effective convoy configuration?

Should every other truck be autonomous? Perhaps only every fourth truck would require a driver?

Just because a technology becomes available doesn't mean it is immediately ready for a role on the battlefield. Tactics and procedures need to be developed to capitalize on new technology. The existing methods for conducting a mission with manned equipment cannot simply be continued with a robot replacing a person. New operational concepts need to be created based on an understanding of both the capabilities and limitations of the robot.



A soldier in the 705th Explosive Ordnance Disposal Company prepares his TALON robot in Mosul, Iraq.

Photo courtesy of Foster-Miller, Inc.

Learning to Work Together

This challenge is compounded when considering robots in different domains working together to conduct a single mission. Much of how the armed forces conduct their missions is predicated on two considerations. First, the domain of air, land, or sea determines how tasks are accomplished, since, for example, conducting reconnaissance from the air is very different from performing that same task on the ground in a jungle environment. The second consideration is how to allocate tasks between people and unmanned equipment when working across the domains. The way DoD currently conducts joint operations will change dramatically when robots are introduced to the inventory. Many tasks for which the Army now relies on Air Force pilots will be conducted by unmanned aerial vehicles, so interactions between the Army and Air Force will likely change dramatically.

Next Steps

The next logical step in the employment of robotic technology is the concept of robots in the air, on the ground, under water, and on the ocean surface, all collaborating to conduct a mission. It's easy to envision these autonomous systems working together, but the actual techniques needed to manage interactions between the systems are still very much in their infancy. If unmanned ground, surface, and aerial vehicles are working together to conduct a river-based reconnaissance mission, how do the ground and the surface vehicles react if the aerial vehicle loses communications because vegetation is thicker than originally believed? Do the remaining vehicles continue the mission, or do they stop in place to await restoration of communications? When people are taken out of the mission equation, the military techniques and procedures that robots follow will not always be the same as personnel have previously used to conduct the same type of mission. New operating procedures and tactics will have to be developed.

Fortunately, experimentation with new technology is nothing new for DoD. A variety of opportunities and tools are available to determine how best to answer the types of questions posed above. In addition to creating robots, DoD is creating virtual environments in which actual software algorithms that control the robots and provide the ability to conduct tactical behaviors, such as reconnaissance can be tested before spending the funds to build a complete robot. These virtual environments help refine the software algorithms and provide a greater number of personnel experience with robotic behavior, so operational issues can be more fully explored.

As powerful as these virtual environments are for exploring concepts and testing the effectiveness of software-controlled behaviors, sometimes there is no substitute for live experimentation. Potential user experimentation with robots is uncovering operational insights that can

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demonstrate a need for technology that was not originally considered. Users invariably take into account operational aspects that don't occur to the scientists and engineers developing the robots, so an opportunity to experiment with the technology while it is still maturing leads to fielding more effective and suitable robots.

When looking at the robotic convoy concept, for example, users indicated a strong preference for the robots to be able to operate at night. When human drivers conduct night convoy operations, they have to be able to see. Robots have a variety of means to "see" in the dark that can potentially provide the convoy with greater capability for nighttime operations than would normally be possible with human drivers. The potential for traveling with shorter distances between vehicles to enable greater security, the ability to travel without giving off much light to avoid revealing the presence of the convoy in the dark, and the ability to travel at higher speeds yet with greater safety are all benefits the robotic convoy technology can potentially deliver. Live experimentation will help users decide which benefits are most helpful in enabling them to conduct their convoy missions with greater effectiveness and lower risk than they do today. DoD can then focus and prioritize robotic convoy development efforts accordingly.

The list of potential jobs for robots in national security varies widely, but the increasing role of robots gives soldiers, Marines, sailors, and airmen the ability to conduct their missions with much less risk. Even though there are thousands of robots already in the inventory, DoD has barely scratched the surface of what is possible. The expectation over the next 10 years is that DoD will integrate robotic technology into many types of missions, and robots will take their place alongside military personnel in keeping the United States safe and secure.

The author welcomes comments and questions and can be contacted at ellen.purdy@osd.mil. For more information on DoD's work with robotics, go to www.jointrobotics.com.